

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

23 April 2013 (am)

Subject ST9 – Enterprise Risk Management

Time allowed: Three hours

INSTRUCTIONS TO THE CANDIDATE

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all seven questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

AT THE END OF THE EXAMINATION

Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.

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| <p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p> |
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- 1** (i) Outline different protection measures that government regulators can implement for financial services companies. [4]

Insurance Company A's risk management department focuses its activities only on meeting government regulatory requirements.

- (ii) Explain the benefits for the insurer if the risk department also started to take account of other stakeholders. [4]
[Total 8]

- 2** A small general insurance company, which writes only property insurance, has decided to use risk maps as part of its risk identification and assessment process.

- (i) Describe the process of developing and implementing a risk map. [5]
- (ii) (a) Give two contrasting examples of risks to which the insurance company may be exposed.
- (b) Sketch them on a risk map. [4]

As a result of this process, the insurer has decided to reduce the risks to which it is exposed but without increasing its counterparty risk.

- (iii) Recommend actions that it may take in order to achieve this. [6]
[Total 15]

- 3** Solvania is a large European country that has decided to change the way in which its universities are financed.

Following many years of growth in the number of university students, the government has decided to scale back the funding that it has traditionally provided to the universities. In order to replace the lost funding, the universities will be allowed to charge substantial tuition fees. This policy has drawn protests across the country. Despite these protests the new tuition fees will be charged for the first time next year, having been approved by the government.

One such university, the Solvania Institute of Arts and Drama, is particularly popular with overseas students and ranked 15th out of the 45 universities in Solvania for academic quality. It is looking to raise debt finance to fund the construction of additional student accommodation. Whilst the new accommodation will be built on the university's out-of-town campus, it will be separated from the other university buildings by a busy major road. The accommodation can be reached by a 15 minute walk or more quickly by a footbridge over the road.

The proposed loan will have the following features:

- The amount of the loan will be £40m to cover the cost of construction of additional student accommodation on campus.
- The interest rate payable on the loan will be 4% above the relevant Solvanian interbank rate.
- The loan to value ratio will be 70%, with full amortisation over the 35 year term.
- The security for the loan will be a 50 year leasehold on the student accommodation.
- After completion, the ratio of students to available beds will be 3 to 2 (compared to 2 to 1 currently).
- Rental income from the student accommodation will be used to service the payments on the mortgage; the ratio of rental income to loan payments is estimated to be 150%. It is further estimated that this would fall to 100% should the student to bed ratio fall to 6 to 5.
- The rents charged to students will normally increase in line with the country's retail price inflation index plus 1%, with all changes being subject to a minimum and maximum increase of 0% and 5% respectively.

The construction company has experience of similar construction projects and a credit rating of A+. The university has a BBB credit rating and extensive gearing of its balance sheet to support the recent development of its academic and accommodation facilities.

The National Bank of Solvania ("NBS") is a multinational bank with major operations in Solvania, including significant experience underwriting commercial mortgages. Typically these commercial mortgages are written with an interest rate that is 2% above the relevant Solvanian interbank rate. However, the bank has now been invited by an intermediary to underwrite the above loan, which represents a divergence from its usual commercial mortgage business.

- (i) Discuss the risks to the bank which will arise from underwriting the loan. [18]

The bank wishes to test how well the loan would perform under stressed conditions.

- (ii) List the sensitivities and scenarios that should be investigated. [3]
[Total 21]

The Solvanian Life Assurance Society (“SLAS”) primarily writes term assurance business, which it largely reinsures, and a small volume of immediate annuity business. It operates a defined benefit pension scheme for its employees, which guarantees to pay employees one 40th of their final salary for each year of service. Following the introduction of a risk-based capital regime, SLAS is considering how to manage its risks better.

(ii) Describe ways in which SLAS could mitigate its longevity risk.

[8]

Following a large drop in the value of its assets, the surplus assets on the Society’s risk-based balance sheet have reduced substantially.

SLAS has entered into discussions with the National Bank of Solvania (“NBS”) to investigate the possibility of improving the surplus assets by transferring longevity risk to the capital markets.

NBS has proposed a non-standard longevity swap with the following features:

- The term of the swap is ten years.
- The longevity swap does not protect SLAS from small changes in the mortality rates.
- However, once mortality rates have improved by 10% the longevity swap protects SLAS from further improvements in mortality rates up to a limit of a 20% improvement in mortality rates.
- The reference mortality rates are those published by Solvania’s National Statistics Office for the population as a whole, as at the start and end of the swap period. The weight given to each age will reflect the actual ages of SLAS’s annuitants.
- SLAS immediately pays NBS a premium for the longevity swap.
- SLAS does not receive or make any payments during the ten year term.
- SLAS receives a maturity payment from NBS at the end of the ten year term, although this maturity payment may be zero.
- After ten years, if the reference mortality rates have improved by more than 10%, SLAS receives a payment equal to any excess of the value of the liabilities at that date over the value of the liabilities assuming a 10% improvement in mortality rates. The maturity payment is subject to a maximum limit equal to the value of the liabilities assuming a 20% improvement in mortality rates less the value of the liabilities assuming a 10% improvement in mortality rates.
- In valuing the liabilities at maturity, differences between the “actual” (reference rates at maturity) and “expected” (reference rates at outset) mortality rates over the ten years are to be extrapolated. There is some flexibility regarding the method of extrapolation, although this must be agreed up front between NBS and SLAS.

- (iii) Illustrate SLAS's profit profile under the longevity swap for varying mortality rates. [4]
 - (iv) Discuss the advantages and disadvantages to SLAS of structuring the longevity swap in this way. [10]
 - (v) Give reasons why SLAS may seek to transfer longevity risk to the capital markets rather than to a reinsurer. [4]
- [Total 27]

5 Southwest Re is a start-up reinsurance company that is assessing its economic capital using a Value at Risk approach calibrated to the 95th percentile loss over one year.

During its first year, Southwest Re underwrote four excess of loss reinsurance treaties with the following features:

| | <i>Excess</i> | <i>Probability of no loss occurring (i.e. below excess)</i> |
|--------------------|---------------|-----------------------------------------------------------------|
| Cornwall Insurance | £50m | 0.995 |
| Devon Insurance | £50m | 0.985 |
| Somerset Insurance | £50m | 0.975 |
| Dorset Insurance | £50m | 0.965 |

Claims on the reinsurance treaties are assumed to be linked by a Gumbel copula with parameter $\alpha = 2.5$.

The generator function for a Gumbel copula with parameter α is:

$$G_{\alpha}\Psi_{\alpha}(F(x)) = [-\ln(F(x))]^{\alpha}$$

The Chief Capital Officer has suggested that, because the probability of no losses occurring on the four reinsurance treaties is greater than 95%, the reinsurer does not need to hold any economic capital.

- (i) Verify the Chief Capital Officer's claim that the probability of no losses occurring on the four reinsurance treaties is greater than 95%. [4]
 - (ii) State with reasons whether the reinsurer should hold capital in respect of the reinsurance treaties, including consideration of the parameterisation of the copula. [6]
- [Total 10]

- 6 (i) Outline how governments and stock exchanges have mitigated or transferred liquidity risk. [3]
- (ii) Describe the possible consequences of liquidity risk crystallising. [3]
- (iii) State with reasons the most common cause of sudden illiquidity in a banking system. [2]
- [Total 8]

7 A financial adviser has produced the following calculations for a client who is considering investing in a portfolio of bonds with one year to maturity.

| <i>Bond</i> | <i>Current Price</i> | <i>Coupon</i> | <i>Probability of Default</i> | <i>Loss Given Default</i> |
|-------------|----------------------|---------------|-------------------------------|---------------------------|
| A | 90 | 3% | 5.0% | 100% |
| B | 95 | 5% | 4.0% | 100% |
| C | 103 | 11% | 3.5% | 100% |
| D | 98 | 7% | 3.0% | 100% |

Note:

- All of the bonds have one year to maturity.
- All of the bonds pay par (100) plus the coupon at maturity.
- They are large issues, with no structural complications, and are widely traded on a major exchange.

$$\begin{aligned} \text{Maximum Return} = & ((100 - 90 + 0.03 \times 100) \times 100/90 \\ & + (100 - 95 + 0.05 \times 100) \times 100/95 \\ & + (100 - 103 + 0.11 \times 100) \times 100/103 \\ & + (100 - 98 + 0.07 \times 100) \times 100/98)/400 = 10.5\% \end{aligned}$$

$$\begin{aligned} \text{Expected Return} = & ((100 - 90 + 0.03 \times 100) \times 100/90 \times (1 - 0.05) \\ & + (100 - 95 + 0.05 \times 100) \times 100/95 \times (1 - 0.04) \\ & + (100 - 103 + 0.11 \times 100) \times 100/103 \times (1 - 0.035) \\ & + (100 - 98 + 0.07 \times 100) \times 100/98 \times (1 - 0.03))/400 \\ & - (0.05 + 0.04 + 0.035 + 0.03) \times 100/400 = 6.2\% \end{aligned}$$

$$\begin{aligned} \text{Return if only bond A defaults} = & ((100 - 95 + 0.05 \times 100) \times 100/95 \\ & + (100 - 103 + 0.11 \times 100) \times 100/103 \\ & + (100 - 98 + 0.07 \times 100) \times 100/98)/400 \\ & - 0.25 = -18.1\% \end{aligned}$$

$$\text{Return if only bond B defaults} = -17.2\%$$

$$\text{Return if only bond C defaults} = -16.5\%$$

$$\text{Return if only bond D defaults} = -16.8\%$$

Probability all bonds default = $0.05 \times 0.04 \times 0.035 \times 0.03 = 0.0002\%$

Probability no bonds default = $(1 - 0.05) \times (1 - 0.04) \times (1 - 0.035) \times (1 - 0.03)$
 $= 85.4\%$

Probability the two riskiest bonds only default = $0.05 \times 0.04 \times (1 - 0.035)$
 $\times (1 - 0.03)$
 $= 0.2\%$

Probability of an AA rated bond defaulting in one year = 0.2%

Current yield to redemption on a one year AA rated bond = 2%

- (i) Outline the points that the financial adviser is likely to make in discussion with the client, based on the above calculations. [5]

After the initial conversation with the client, one of the financial adviser's colleagues produced the following two sets of calculations for the client.

$$Pr(F(x_1), F(x_2), \dots, F(x_N)) = -\frac{1}{\alpha} \ln \left[1 + \frac{\prod_{n=1}^N (e^{-\alpha F(x_n)} - 1)}{(e^{-\alpha} - 1)^{N-1}} \right]$$

If $\alpha = 8$ then:

$Pr(\text{all bonds default}) =$

$$-\frac{1}{8} \ln \left[1 + \frac{(e^{-8 \times 0.05} - 1)(e^{-8 \times 0.04} - 1)(e^{-8 \times 0.035} - 1)(e^{-8 \times 0.03} - 1)}{(e^{-8} - 1)^3} \right]$$

$= 0.06\%$

$Pr(\text{the two riskiest bonds only default})$

$= 1.18\%$

OR

$Pr(\text{exactly two bonds default}) =$

$$(1 - e^{-\lambda_{12}}) e^{-(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_{13} + \lambda_{14} + \lambda_{23} + \lambda_{24} + \lambda_{34} + \lambda_{123} + \lambda_{124} + \lambda_{134} + \lambda_{234} + \lambda_{1234})} +$$

$$(1 - e^{-\lambda_{13}}) e^{-(\lambda_1 + \dots)} +$$

$$(1 - e^{-\lambda_{14}}) e^{-(\lambda_1 + \dots)} + \dots$$

$= 0.76\%$

- (ii) State the processes or models underlying these new calculations. [2]
- (iii) Interpret the results of the three different sets of calculations. [2]
- (iv) Outline the follow up points that the financial adviser should make to the client as a result of the new calculations. [2]

[Total 11]

END OF PAPER